

Psychological consequences of Traumatic Upper Limb Peripheral Nerve Injury: A Systematic Review

Miller, Caroline; Peek, Aimie; Power, Dominic; Heneghan, Nicola

DOI:

[10.1177/1758998316679387](https://doi.org/10.1177/1758998316679387)

License:

None: All rights reserved

Document Version

Peer reviewed version

Citation for published version (Harvard):

Miller, C, Peek, A, Power, D & Heneghan, N 2016, 'Psychological consequences of Traumatic Upper Limb Peripheral Nerve Injury: A Systematic Review', *Hand Therapy*, vol. 0, no. 0, 0, pp. 1-11.
<https://doi.org/10.1177/1758998316679387>

[Link to publication on Research at Birmingham portal](#)

General rights

Unless a licence is specified above, all rights (including copyright and moral rights) in this document are retained by the authors and/or the copyright holders. The express permission of the copyright holder must be obtained for any use of this material other than for purposes permitted by law.

- Users may freely distribute the URL that is used to identify this publication.
- Users may download and/or print one copy of the publication from the University of Birmingham research portal for the purpose of private study or non-commercial research.
- User may use extracts from the document in line with the concept of 'fair dealing' under the Copyright, Designs and Patents Act 1988 (?)
- Users may not further distribute the material nor use it for the purposes of commercial gain.

Where a licence is displayed above, please note the terms and conditions of the licence govern your use of this document.

When citing, please reference the published version.

Take down policy

While the University of Birmingham exercises care and attention in making items available there are rare occasions when an item has been uploaded in error or has been deemed to be commercially or otherwise sensitive.

If you believe that this is the case for this document, please contact UBIRA@lists.bham.ac.uk providing details and we will remove access to the work immediately and investigate.

Psychological Consequences of Traumatic Upper Limb Peripheral Nerve Injury: A Systematic Review

Abstract

Introduction

Traumatic upper limb Peripheral Nerve Injuries (PNI) significantly impact individuals' function and ability to return to work. Individuals experience ongoing psychological impairments for which they are not routinely treated. The aim of this review was to investigate the psychological consequences of traumatic upper limb PNI

Methods

A systematic review of MEDLINE, Embase, PsycINFO, CINAHL, AMED, BNI, the Cochrane libraries and grey literature up to October 2015 was undertaken. Two reviewers independently assessed methodological quality using an assessment tool and scored it in accordance with Cochrane Collaboration recommendations. Eligibility criteria comprised: adults or adolescents with traumatic upper limb PNI using any measurement of psychological well-being.

Results

Six studies (n=245) met the inclusion criteria. Methodological quality varied widely. Evidence of PTSD (Post Traumatic Stress Disorder) at one month, which decreased over time, was reported by three studies. Two studies found a statistically significant correlation between the early presence of PTSD and reduction in function at 12 or more months. Limited information was available on anxiety, depression and mental quality of life. Combined nerve injuries (in two studies) had significantly higher levels of PTSD, at one month, compared to those with an isolated nerve injury.

Conclusion

There is some evidence of early PTSD following traumatic upper limb PNI which may have an impact on functional outcome. However, high quality studies using prospective cohorts are required to further evaluate the psychological aspects associated with this traumatic injury.

Keywords

Peripheral nerve injury, Upper limb, Psychological distress, post-traumatic stress disorder, systematic review

INTRODUCTION

Nerve injuries are common in those who experience severe hand or arm trauma. With 69% of patients with upper limb trauma presenting with nerve injury (1), the disability related socioeconomic and personal costs are considerable [1–3]. A recent economic study in Sweden estimated that healthcare and loss of production costs €29,000 and €75,000 respectively, per patient with traumatic upper limb Peripheral Nerve Injury (PNI) [1]. Whilst early management is primarily medically focused, there is a need to understand other factors, which may influence outcomes for this patient population; such factors include the psychological impact of traumatic upper limb PNI. Psychological impairments are reported to affect patients' perceived general health more than the degree of physical function or severity of the injury [4, 5]. Although this lends support to a bio-psychosocial approach to the management of traumatic upper limb PNI we need to have knowledge of the scope of psychological consequences to optimise interventions through targeted personalised management.

The upper limbs and specifically the hands are a significant part of perceived body image, contributing to communication and function [6, 7]. Traumatic upper limb PNI may result in lifelong cosmetic and functional deficits to the hands, something Grunert et al [8] reported in patients following severe hand injuries. Given the significant functional role the hand plays it may also affect an individual's self-worth [9]. Gustafsson & Ahlstrom [10] reported that, at one year post injury, 17% of a sample (n=91) of patients with traumatic hand injuries had high levels of 'intrusion' or 'avoidance' as defined by the Impact of Event Scale (IES) ≥ 19 . Clinical depression has also been reported following traumatic upper limb PNI, with 39% of patients (n=49) scoring above the threshold for depression on the Centre for Epidemiologic Studies Depression Scale (CESDS) (≥ 16) [11].

Interviews of patients with traumatic upper limb PNI found a range of ongoing symptoms such as *flashbacks*, *nightmares*, *feelings of sadness* and *hopelessness* [12]; symptoms not captured by existing patient reported outcome measures such as the IES and CESDS. Patients also reported feeling withdrawn from social events decades following the injury [12]. It is likely that psychological consequences of traumatic upper limb PNI may go undetected during clinical assessment, which could affect long-term clinical outcomes, Quality of Life (QoL) and a patient's ability to return to work. There is therefore a need to synthesise the evidence on the psychological impact, namely anxiety, depression and post-traumatic stress in patients following traumatic upper limb

PNI. Knowledge of these impairments and their impact on function could be used to inform future practice. More specifically there is a clinical need to develop patient reported outcome measures, which captures the scope and nature of psychological consequences in traumatic upper limb PNI.

The aims of this systematic review were to:

- (i) establish the prevalence of anxiety, depression and post-traumatic stress disorder (PTSD) following traumatic upper limb PNI;
- (ii) explore the impact psychological consequences have on function, QoL and return to work
- (iii) identify where there are gaps in the understanding of the psychological consequences of traumatic upper limb PNI.

METHODS

Search strategy

The search strategy, selection of studies, assessment of risk of bias and reporting of results for the review were conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) statement [13, 14]. The protocol was prospectively registered with PROSPERO (accepted on 12 January 2015; Registration no: CRD42016027836). The following databases were systematically searched individually from inception through to October 21, 2015 by lead investigator (CM): MEDLINE, Embase, CINAHL, AMED, BNI, PsycINFO, Cochrane databases and PubMed. Grey literature was searched using Google Scholar and the National Bibliography Library for abstracts and theses. There was no limitation of date or language. Reference lists of included articles were screened. The journals Hand Therapy, Journal of Hand Therapy, British Journal of Hand Surgery, Journal of Hand Surgery (Am) were hand searched to identify any additional articles. In addition two years of conference proceedings from the British Association of Hand Therapy and British Society of Surgery for the Hand were screened. A comprehensive search strategy was developed from scoping searches with search terms agreed *a priori* through discussion with subject (DP) and methodological specialists (NH). It comprised of the following elements: upper limb, peripheral nerve, injury, trauma, disability, anxiety, depression and Post Traumatic Stress Disorder and QoL.

Eligibility criteria

Two authors (CM, AP) independently reviewed the articles obtained by the search for eligibility and possible inclusion. The titles, abstracts and full texts were screened for eligibility based on the criteria listed below. This was facilitated by grading each study as eligible/not eligible or might be eligible. In cases of eligibility uncertainty, the full text of the manuscript was screened for inclusion.

Inclusion criteria

The following inclusion criteria were used to screen and select studies for inclusion.

- **Participants:** Studies on adolescents and adults with a diagnosis of traumatic injuries to the median, ulnar, radial and musculocutaneous nerves. This included studies of mixed populations whereby it was possible to extract traumatic upper limb PNI data.
- **Types of studies:** Any study where the primary aim was to examine psychological outcomes e.g. anxiety, depression or PTSD, post traumatic injury of the aforementioned peripheral nerves in the upper limb.
- **Outcome measures:** inclusion of a validated outcome measure of psychological impairment e.g. depression, anxiety or PTSD.

Exclusion criteria

Studies were excluded which assessed psychological outcomes in participants with

- Entrapment syndromes such as cubital tunnel and carpal tunnel
- Brachial plexus injuries
- Cervical nerve root pathology
- Isolated digital nerve injuries
- Nerve injury or pathology secondary to tumour

Data extraction

CM completed the data extraction and AP checked all the data for accuracy. The information extracted included: participants (setting and area), sample source and size, inclusion exclusion criteria, study design, patient characteristics (age, ethnicity, socioeconomic, gender, etc.) method of recruitment, diagnosis and surgery, follow up time, outcomes (including scale and name of questionnaire/ instrument), number included in follow up, withdrawals and loss to follow up, statistical techniques, conclusion and relevant methodological limitations. A Microsoft Excel document was used to manage the data extraction. Authors of included studies were contacted for missing data.

Assessing quality of studies

A small pilot study determined the most appropriate quality assessment tool to use with the included studies. Two investigators (CM and AP) piloted a quality assessment tool developed by Moran [15] and the Newcastle Ottawa Scale [16] with two of the included studies. From this pilot we excluded the Newcastle Ottawa Scale [16] as questions in two categories (selection and comparability) were not appropriate to the methodology in the included studies.

The quality assessment tool developed by Moran [15] comprises of 18 items and focuses on sampling, measurement of outcomes, attrition and analysis. Each item is scored as a Yes/No/Unclear or Not Applicable as recommended by Cochrane [17]. Two investigators independently scored the included studies and then discussed each checklist item for each study. A third reviewer (NH) was used in instances of disagreement. Percentage agreement was calculated to determine initial agreement between the reviewers for each item.

Data analysis and synthesis

Synthesis focused on evaluating the psychological consequences of traumatic upper limb PNI, investigating predictors of these psychological consequences and whether such psychological impairments were predictors of functional outcome. Descriptive analysis was conducted and data was synthesised.

RESULTS

Literature search

Fig 1. Illustrates a flow diagram depicting the search and the review process. Of the initial 716 articles retrieved from electronic and hand searches, six articles were identified as having met the inclusion and exclusion criteria. Five articles [18–22] were identified through the electronic search while one article [23] was identified through hand search.

Study characteristics

The characteristics of included studies are displayed in Table 1. Of the 6 studies selected for analysis, one originated from Italy [23] and one from Sweden [19]. Four studies originated from the Netherlands from two different research groups: Jaquet et al [18, 22], Hundepool et al [20] and Ultee et al [21]. A total of 245 participants were included; this includes a sample of 61 who were reported in both published studies by Hundepool et al [20, 21] investigating different psychological outcomes. Study designs included four retrospective cohort studies [18, 19, 22, 23] and two prospective cohort studies [20, 21]. All patients were recruited using convenience sampling from specialist trauma centres.

Participants

All participants (n= 245) had experienced a traumatic upper limb PNI. Four of the studies included only traumatic median and/or ulnar nerve injuries in the forearm [18, 20–22]. In the other two studies outcomes of participants with traumatic upper limb PNI were analysed separately to participants with other traumatic injuries [19, 23]. Diagnoses in these two studies included analysis of traumatic radial, ulnar, median and musculocutaneous nerve injuries [19, 23]. Five studies (n=235) disclosed gender (male = 191; female = 44)[18–22].

Risk of bias

Two reviewers (CM, AP) initially agreed on 100/108 (93%) of items on the quality assessment checklist. Differences in scoring were resolved through discussion and involvement of third investigator (NH). Following this 100% agreement was reached. Assessment of the risk of bias revealed that the sampling domain was the weakest; no studies reported how the sample size was calculated and consequently it was unclear if sample size was adequate. Additionally, evidence of pre-existing psychological impairment before traumatic upper limb PNI was unknown. A summary of the quality assessment is provided in Table 2.

Outcomes

Outcome measures assessing psychological factors included Impact of Event Scale (IES), which was used in four studies [18, 20–22]. Depression was assessed in only one study [23], which used the Beck Depression Inventory. Cederlund et al [19] analysed mental quality of life using the SF-36 and also assessed sense of coherence. Sense of coherence

is described as an individual's disposition towards life and has been shown to influence outcome post surgery [24]. Functional outcomes were measured by Hundepool et al [20], Jaquet et al [22] and Ciaramitaro [23] who used the Disabilities of the Arm Shoulder and Hand (DASH), the Functional Symptom Score and the Rankin respectively. Time to return to work was assessed by Jaquet et al [18].

Post Traumatic Stress Disorder

Post Traumatic Stress Disorder was measured in four studies [18, 20–22]; these studies all assessed the presence of PTSD using the IES. Within the included studies scores over 30 on the IES are considered in need of psychological input. Evidence of PTSD was reported for three studies at one month [18, 21, 22]. An overall decrease in PTSD was observed across studies over time (Table 3).

Predictors for Post-Traumatic Stress Disorder following traumatic upper limb peripheral nerve injury

Two studies [21, 22] reported that, at one month, combined median and ulnar nerves injuries were accompanied by higher psychological stress. Jaquet et al [22] reported high mean IES scores of ($>30 \pm 20.3$ SD) compared to single nerve injuries: median nerve (mean IES 24.3 ± 20.6 ; $p = 0.049$), ulnar nerve (mean IES 22.6 ± 19.5 ; $p = 0.021$). Similarly, Ultee et al [21] recently found, at one month, that patients with combined nerve injuries had high IES (mean 37.5 ± 16.2), which was significantly different to those who injured an isolated nerve ($p < 0.05$). No studies found a difference in the presence of PTSD between patients with isolated median and those with ulnar nerves injuries [21, 22].

Female gender was found to be a predictor of the presence of PTSD post traumatic upper limb PNI in two studies [21, 22]. Using multiple linear regression Jaquet et al [22] and Ultee et al [21] established that gender was an independent predictor of post-traumatic psychological stress ($\beta = 12.9, p = 0.008$ and $F = 5.45, p = 0.023$ respectively). One study [21] reported that at 3 months post surgery increasing age was a significant independent predictor for ongoing psychological stress ($F = 7.68, p = 0.007$).

Jaquet et al [22] found higher education was a protecting variable for PTSD ($\beta = -0.23$; 95% CI -6.05 to -0.246)). Patients who attempted suicide in one study [22] reported higher scores on the IES (mean 34.7 ± 35.8 points, however, this was not statistically significant ($p = 0.234$)). Location of the nerve injury in the forearm was found not to be

associated with psychological stress injury in one study [21]. Specific location (e.g. proximal, middle or distal) was not reported in this study.

Depression and other psychological factors

Two studies assessed depression and QoL following traumatic upper limb PNI [19, 23]. Ciaramitaro [23] found that Beck Depression Inventory scores were higher in those patients with pain ($p=0.0008$) compared to those who were pain free. Patients with radial and ulnar nerve injuries had the highest percentage of reported pain amongst those with traumatic upper limb PNI in this study. A trend towards lower scores in SF-36 mental subtest and SF36-total was also evident in patients with pain compared to those without. Beck Depression Inventory scores were strongly correlated to pain (Coefficient 1.03; $p < 0.0001$).

Cederlund et al [19] found that patients with traumatic upper limb PNI had poorer social functioning (SF-36) when compared to participants without a nerve injury in the upper limb at 12 months following injury ($p = 0.02$). There was no significant difference in the SF-36 dimensions measuring emotional role and mental health at 3, 6 and 12 months follow up, between these two groups of patients. However, in both groups mental QoL did not reach population norms by 12 months.

Only one study [19] assessed individual factors, which may influence outcome following traumatic upper limb PNI. Cederlund [19] found that individuals with a low sense of coherence showed significantly lower satisfaction in daily occupations ($p= 0.030$), higher DASH scores ($p=0.069$) lower mental QoL on SF36 ($p=0.001$) more sleep disturbances ($p=0.003$) and bodily pain ($p=0.035$) at 12 months post injury.

Psychological factors as a predictor of outcome

Two studies [20, 22] assessed whether the presence of early PTSD affected power and pinch grip following traumatic upper limb PNI. Hundepool et al [20] measured strength at one year and Jaquet et al [22] assessed it at a mean of 5.5 years after traumatic upper limb PNI. Hundepool et al [20] and Jaquet et al [22] found, using multivariate regression analysis, lower levels of PTSD (assessed using the IES at one month) predicted higher power grip: $\beta = - 0.352$; $\beta = 0.37$ (95% CI 0.09 to 0.65; $p < 0.01$) respectively. With regards to pinch grip, Jaquet et al [22] found an association of $\beta = 0.46$ (95% CI 0.13 to 0.80; $p = 0.007$). However, in Hundepool et al's recent prospective study [20] the authors found only a weak negative correlation of $r = - 0.257$ ($p = 0.046$) between early signs of PTSD and pinch grip.

Three studies assessed whether psychological factors had an effect on function [20, 22, 23]. Ciaramitaro et al [23] did not separate upper limb PNI data with respect to function from the rest of the data, however these authors found that across the whole group of traumatic peripheral nerve injuries that BDI was not correlated with disability using the Rankin Coefficient 1.4; (95% CI -1.02 to 3.9; $p=0.245$). Hundepool et al [20] found that the degree of PTSD at one month ($r=0.446$, $p<0.001$) and 3 months ($r=0.423$, $p=0.001$) had a significant positive correlation with DASH at 12 months. Results from Jaquet et al [30] support this and demonstrated a positive correlation ($\beta=0.51$; 95% CI 0.35 to 0.65; $p<0.001$) between the IES score and Functional Symptom Score at a mean of 5.5 years. Psychological factors were not found to be a predictor of sensory recovery in two studies [20, 22].

One study [22] assessed whether psychological impairment had an effect on return to work. Jaquet et al [22] found a significant difference ($p>0.001$) between return to work (at one year) in patients with a minor (<18) and severe (>40) IES score at one month. Patients with minor IES scores had 23.5 weeks off work compared to 45.3 in patients with severe IES scores.

Discussion

To the best of the authors' knowledge this is the first systematic review to synthesise evidence on the psychological consequences of traumatic upper limb peripheral nerve injury. The findings provide confirmation of ongoing psychological stress in this patient group, which supports other reports following traumatic upper limb PNI [11, 12, 25]. PTSD was the most common psychological consequence studied after traumatic upper limb PNI. There was evidence of significant symptoms of PTSD early after PNI and these symptoms decreased over the first year. There was only one study [23], which assessed depression after traumatic upper limb PNI reporting some evidence of a correlation with pain. However, overall the findings are limited as few high quality studies exist and those studies included varied methodology.

Participants

Participants were all recruited from specialist trauma centres and had experienced a nerve injury, which would be classified as a neurotmesis or axontmesis [26]. This precludes generalisation to patients with minor nerve injuries such as neurapraxia however minor nerve injury as a result of trauma is rare [27]. Furthermore, all studies assessing PTSD using the IES recruited participants from the Netherlands [18, 20–22]. Cultural differences have been shown to exist when analysing results from IES scores

[28]. One study found that, after prostate cancer, African American men had consistently higher levels of IES compared to non African American men [28]. This is an important consideration and therefore it may not be possible to generalize frequency episodes of PTSD to the UK population.

Outcomes

PTSD was consistently assessed by the IES in the included studies, however its appropriateness needs to be considered. The IES is a self-report questionnaire that consists of 15 items, which measure intrusive re-experiences of the trauma and avoidance of trauma-related stimuli [29]. Although Horowitz et al [29] reported that a score of 26 was indicative of a moderate post-traumatic stress reaction, more recently this has been disputed. Wolfforth et al [30] showed that a cut-off score of 35 on the total IES-score produced sensitivity of 0.89, specificity of 0.94 when criteria of the Diagnostic and Statistical Manual of Mental Disorders –IV are met for PTSD. Studies included in our review used a cut off of 30 on the total IES [18, 21, 22]. Because of this difference in cut off scores in the literature and in the included studies there may well have been an overestimation in the prevalence of PTSD. Similarly, as IES only measures two of the three main PTSD symptoms (intrusion and avoidance) then it has been suggested by some authors that it cannot be used to diagnose PTSD but may indicate a probability of PTSD [31]. Therefore, IES may not be a suitable screening tool for PTSD in individuals with traumatic upper limb PNI.

Prevalence of psychological distress

Across all studies [18, 21, 22] assessing PTSD, a relatively high frequency of PTSD was observed (91-100%) which decreased overtime. This decline in psychological distress is similar to that seen in the hand trauma [8, 10] and whiplash literature [32]. The prevalence of PTSD in the general musculoskeletal trauma population has been estimated to be in the range of 19.5% - 51% [33]. However, it is difficult to compare prevalence with other studies following trauma as differing outcomes, cut-offs and time points have been used. In a study by Opsteegh et al [34] symptoms of PTSD were assessed using the Self –Rating Scale PTSD. This study [34] found that 66% (n= 67) of patients following a hand injury reported symptoms of PTSD.

An important consideration is the lack of comparator group for all included studies except one [19]. Consequently, it was not possible to determine if prevalence of psychological distress in patients with traumatic upper limb PNI is higher than prevalence for age and sex stratified subjects in the general population. Furthermore, mechanism of injury and the evaluation of mental health prior to PNI were not assessed

fully in the included studies. It is recognised in the literature that individuals who experience work-related injuries [10, 35, 36] and those with pre-existing or a family history of psychological impairment [37] have an increased risk of developing symptoms of PTSD post trauma. Three studies in this review [18, 20, 22] excluded subjects who attempted suicide or with known psychological diseases from their analysis concerning IES. Inclusion of patients who attempted suicide may lead to misinterpretation of the results. This is an important consideration as incidence of PTSD in injured adults has been shown to have a strong correlation with assault and poor mental health [4, 38]. Furthermore, Jaquet et al [18, 22] used retrospective data where patients remembered on average 10 years back to the injury time and report on the IES. There is evidence that this retrospective method of measuring change with outcome measures could be associated with larger changes in scores [39].

Predictors of psychological distress and impact on function, quality of life and return to work

In this review, notwithstanding the recognised relatively low quality of evidence, pain [23] female gender and older age [21, 22] were found to be potential predictors of developing a psychological impairment in patients with traumatic upper limb PNI. This corroborates findings in the general trauma literature that female gender and increasing age predicted more symptoms of PTSD [35, 36]. Additionally, in a study of 67 patients with traumatic hand injuries Opsteegh et al [34] found that pain and aesthetics were predictive of the presence of PTSD. Two included studies [21, 22] found there was a correlation between combined nerve injuries and higher scores on IES at one-month post injury. This is not supported in the general trauma literature where there is a body of evidence, which concludes that injury severity is not associated with ongoing psychology distress [4, 5]. However concerns over aesthetics and social acceptability following severe hand and upper limb nerve injuries are common [2, 8, 9, 25]. The presence of a nerve injury can result in severe long-term deformities, which are significant and may ultimately contribute towards a larger psychological impact.

The presence of early PTSD was significantly linked with ongoing functional disability at 12 months [20] and one study reported that patients with a high IES had a much higher number of weeks off work compared with those reported lower levels on the scale [22]. These findings are in agreement with general trauma literature [40–42] and also specifically upper limb trauma [43–45]. Only one study [19] assessed how participants' individual personal attributes influenced outcome following traumatic upper limb PNI. Participants with a low sense of coherence had significantly poorer functioning and

quality of life compared to those with a higher sense of coherence. There is a similar trend in the spinal and musculoskeletal literature where self-efficacy and sense of coherence are seen to influence the development of persistent disability [24, 46–48].

Strengths and limitations

The main strength of this work is that it was designed and conducted according to Cochrane [49] and Centre for Review and Dissemination [50] guidelines. There was no language restriction and to reduce publication bias, conference abstracts and theses of unpublished studies were included and grey literature was searched. Authors from included studies were contacted for missing data. At an individual study level there were many limitations which impacts on the reliability and generalisability of the results. Studies were heterogeneous in methodology and there were a small number of studies for most of the outcomes. A further limitation of the review is that analysis was limited to six studies and heterogeneity of inclusion criteria and outcomes assessment precluded meta-analyses.

Clinical implications

Treatment following traumatic upper limb PNI often involves long-term rehabilitation. Hand therapists have a unique role in facilitating physical and psychosocial adjustments. Screening patients for possible post-traumatic stress could assist in identifying patients at risk of poor outcome and ensure timely onward referral for appropriate psychological management. A person's sense of coherence and other factors such as coping can be addressed by hand therapists, who are ideally placed to teach coping strategies, improve patients' confidence in their ability to carry out activities and to influence how patients think about their symptoms. This approach is in line with recommendations in recent musculoskeletal guidelines [51].

Conclusions

This review highlights a high prevalence of PTSD following traumatic upper limb PNI although evidence is currently limited due to the low number and limited quality of the studies. Evidence on the prevalence of other psychological consequences, such as anxiety or depression is generally absent or unclear. There is some support, in the literature that the presence of psychological factors can predict functional outcome or return to work. Other aspects such as coping strategies and inherent personality traits need further investigation. This review found that female gender, older age and combined nerve injuries might be associated with the development of psychological impairment following a traumatic upper limb PNI. Overall, psychological screening and

assessment could be improved by focusing on developing a validated patient reported outcome measure, which is appropriate to patients with traumatic upper limb PNI and amenable to clinical intervention. This evidence synthesis supports the need for further rigorous research, using prospective cohorts, evaluating the psychological consequences of traumatic upper limb peripheral nerve injury.

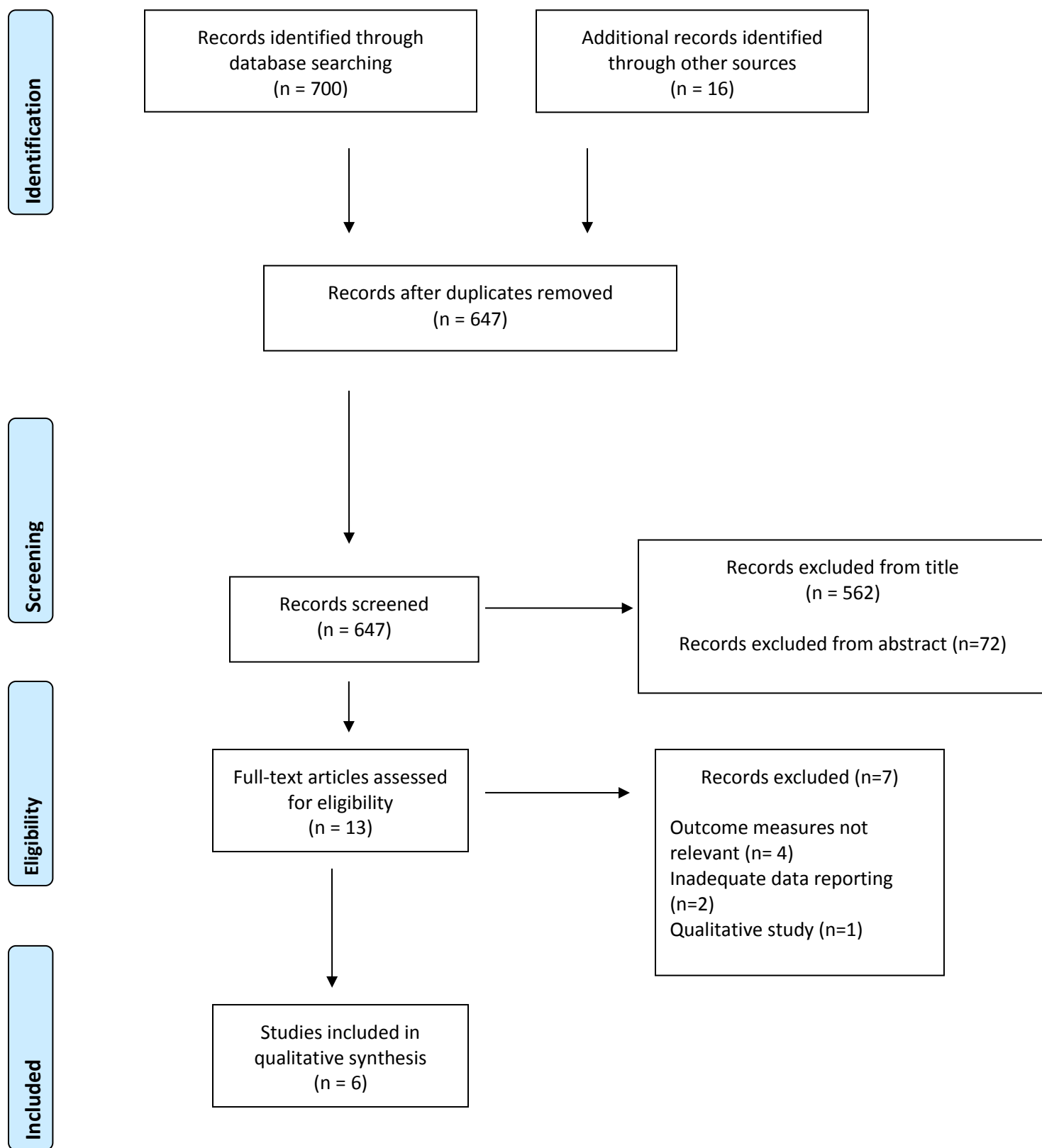


Fig. 1 Flowchart for search strategy

Table 1 Characteristics of included studies

Author	Country	Design	Sample size	Age	Gender	Occupation	Follow Up	Outcomes Measures assessed
Cederlund et al [19]	Sweden	Case series	17	Mean =32 (16-58)	M=13 F = 4	Manual (14); non manual (3)	3, 6, 12 months	HISS, SOC, sleep disturbance, SDO, Cold sensitivity, Health status, EQ5D, DASH, SF36
Ciaramitaro et al [23]	Italy	Case Series	10 (radial =4 ulnar n =4 median =2)	Not disclosed	Unable to assess for forearm injuries	Unable to assess for forearm injuries	Mean 99 days post injury (25-150)	Severity scale seddon. VAS, DN4 (pain), BDI, SF36, Health Survey, mRS, OLNS
Hundepool et al [20]	Netherlands	Prospective case series	61	70.5%< 40 29.5% > 40	M=51 F = 10	85% Blue collar; 15% white collar	1,3,12 months	MRC motor, IES, DASH
Jaquet et al [22]	Netherlands	Case series	107	Mean =30 (+/- 12)	M=85; F =22	Not disclosed	Patient to recall what IES was at one month Followed up at one time Mean 5.5 years (1-10)	IES, DASH, questionnaire concerning RTW and profession
Jaquet et al [18]	Netherlands	Case series	69 cases- 67 patients (50 patients in total completed IES)	Mean =29.1 (+/- 12.4)	M=42 F=8	Not disclosed	Responders Mean 11years (+/- 4.4)	IES, DASH, questionnaire concerning RTW and profession
Ultee et al [21]	Netherlands	Prospective case series	61(median= 30, ulnar= 24, combined =7)	Adolescent (n=23) no mean age Adult (n=38)	M= 51 F =10	Not disclosed	1 and 3 months post surgery/injury	IES

M= male: F=female

HISS: Hand Injury Severity Score; SOC: Sense of Coherence; SDO: Satisfaction with Daily Occupation; DASH: Disabilities of Arm Shoulder and Hand; VAS: Visual Analogue Scale; DN4: Douleur Neuropathique 4; BDI: Beck Depression Inventory; mRS: modified Rankin Scale; OLNS: Overall Neuropathy Scale; MRC; Medical Research Council; IES; Impact of Event Scale

Table 2. Quality analysis of studies using quality assessment tool devised by Moran et al [16]

Questions	Cederlund et al [19]	Ciaramitaro et al [23]	Hundepool et al [20]	Jaquet et al [22]	Jaquet et al [18]	Ultee et al [21]
1. Appropriate Study design	Yes	Yes	Yes	No	Yes	Yes
2. Appropriate sampling	Yes	Yes	Unclear	Yes	Yes	Yes
3. No. of participants approached and agreed to take part	Unclear	No	Yes	Yes	Yes	Yes
4. Participants have similar characteristics to those who refused	Unclear	Unclear	Unclear	Yes	Yes	Unclear
5. Sample size adequate	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear
6. Detail of sample size calculation	No	No	No	No	No	No
7. Suitable definitions ULPNI	Yes	Yes	Yes	Yes	Yes	Yes
8. Control group comparable	N/A	N/A	N/A	N/A	N/A	N/A
9. Outcome present before ULPNI assessed?	No	No	No	No	No	No
10. Suitable measure for outcome	Yes	Yes	Yes	Yes	Yes	Yes
11. Outcome measurement validated for population?	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear
12. Outcome measure cut-off predefined	Yes	No	Yes	Unclear	Yes	Yes
13. Outcome measure admin suitable	Yes	Yes	Yes	Yes	Yes	Yes
14. Potential confounding factors measured	Yes	Yes	Yes	Yes	Yes	No
15. Drop outs documented at each point	Yes	N/A	Yes	N/A	Yes	No
16. Reasons for drop outs/withdrawals	Yes	N/A	No	N/A	No	No
17. All outcomes reported	Yes	Yes	Yes	Yes	Yes	Yes
18. Confounding factors adjusted for	Yes	No	No	Yes	Yes	No

Table 3. Post-Traumatic Stress Disorder following Traumatic Upper Limb Peripheral Nerve Injury

	1 month		3 months		Over 1 year	
Impact of Event Scale	IES mean (SD)	IES Score >30	IES mean (SD)	>30	IES mean (SD)	>30
Ultee et al [21] (n=61)	22 (17.3)	24.6	13.3(14.1)	13.3%	n/a	n/a
Jaquet et al [18] (n= 50)	26.2 (11.2) (P< 0.001)	n/a	n/a		7.3 (11.2) ‡ p<0.001)	n/a
Jaquet et al [22] (n= 107)	25.8 (20.5)	36.1	n/a		6.5 (12.4) *	4%

‡ Average 10 years post injury; * Average 5.5 years post injury

References

- [1] Rosberg HE, Carlsson KS, Cederlund RI, et al. Costs and outcome for serious hand and arm injuries during the first year after trauma - a prospective study. *BMC Public Health* 2013; 13: 501.
- [2] Gustafsson M, Persson L-O, Amilon A. A qualitative study of coping in the early stage of acute traumatic hand injury. *J Clin Nurs* 2002; 11: 594–602.
- [3] Jaquet JB, Luijsterburg AJ, Kalmijn S, et al. Median, ulnar, and combined median-ulnar nerve injuries: functional outcome and return to productivity. *J Trauma* 2001; 51: 687–92.
- [4] Michaels AJ, Michaels CE, Zimmerman MA, et al. Posttraumatic stress disorder in injured adults: etiology by path analysis. *J Trauma* 1999; 47: 867–73.
- [5] Crichlow RJ, Andres PL, Morrison SM, et al. Depression in orthopaedic trauma patients. Prevalence and severity. *J Bone Joint Surg Am* 2006; 88: 1927–33.
- [6] Hannah SD. Psychosocial issues after a traumatic hand injury: facilitating adjustment. *J Hand Ther*; 24: 95–102; quiz 103.
- [7] Lundborg G, Rosén B. Hand function after nerve repair. *Acta Physiol* 2007; 189: 207–217.
- [8] Grunert BK, Smith CJ, Devine CA, et al. Early psychological aspects of severe hand injury. *J Hand Surg Br* 1988; 13: 177–80.
- [9] Grob M, Papadopoulos NA, Zimmerman A, et al. The Psychological Impact of Severe Hand Injury. *J Hand Surg (European Vol)* 2008; 33: 358–362.
- [10] Gustafsson M, Ahlström G. Problems experienced during the first year of an acute traumatic hand injury - a prospective study. *J Clin Nurs* 2004; 13: 986–95.
- [11] Bailey R, Kaskutas V, Fox I, et al. Effect of upper extremity nerve damage on activity participation, pain, depression, and quality of life. *J Hand Surg Am* 2009; 34: 1682–1688.
- [12] Chemnitz A, Dahlin LB, Carlsson IK. Consequences and adaptation in daily life - patients' experiences three decades after a nerve injury sustained in adolescence. *BMC Musculoskelet Disord* 2013; 14: 252.

- [13] Shamseer L, Moher D, Clarke M, et al. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015: elaboration and explanation. *BMJ* 2015; 349: g7647.
- [14] Moher D, Shamseer L, Clarke M, et al. Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA-P) 2015 statement. *Syst Rev* 2015; 4: 1.
- [15] Moran GM, Fletcher B, Calvert M, et al. A systematic review investigating fatigue, psychological and cognitive impairment following TIA and minor stroke: protocol paper. *Syst Rev* 2013; 2: 72.
- [16] Wells GA, Shea B, O'Connell D, Peterson J, Welch V, Losos M, et al. The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analyses. Available from: URL: http://www.ohri.ca/programs/clinical_epidemiology/oxford.htm
- [17] Furlan AD, Pennick V, Bombardier C, et al. 2009 updated method guidelines for systematic reviews in the Cochrane Back Review Group. *Spine (Phila Pa 1976)* 2009; 34: 1929–41.
- [18] Jaquet J, van der Jagt I, Kuypers PDL, et al. Spaghetti wrist trauma: functional recovery, return to work, and psychological effects. *Plast Reconstr Surg* 2005; 115: 1609–1617.
- [19] Cederlund RI, Ramel E, Rosberg H-E, et al. Outcome and clinical changes in patients 3, 6, 12 months after a severe or major hand injury--can sense of coherence be an indicator for rehabilitation focus? *BMC Musculoskeletal Disord* 2010; 11: 286.
- [20] Hundepool C a., Ultee J, Nijhuis THJ, et al. Prognostic factors for outcome after median, ulnar, and combined median–ulnar nerve injuries: A prospective study. *J Plast Reconstr Aesthetic Surg* 2015; 68: 1–8.
- [21] Ultee J, Hundepool CA, Nijhuis THJ, et al. Early posttraumatic psychological stress following peripheral nerve injury: a prospective study. *J Plast Reconstr Aesthet Surg* 2013; 66: 1316–1321.
- [22] Jaquet J, Kalmijn S, Kuypers PDL, et al. Early psychological stress after forearm nerve injuries: a predictor for long-term functional outcome and return to productivity. *Ann Plast Surg* 2002; 49: 82–90.
- [23] Ciaramitaro P, Mondelli M, Logullo F, et al. Traumatic peripheral nerve injuries: Epidemiological findings, neuropathic pain and quality of life in 158 patients. *J Peripher Nerv Syst* 2010; 15: 120–127.

- [24] Pakarinen M, Sinikallio S, Koivumaa-Honkanen H, et al. Low sense of coherence during postoperative recovery is associated with a poorer lumbar spinal stenosis - surgical outcome: A 5-year follow-up study. *J Health Psychol*. Epub ahead of print 1 October 2015. DOI: 10.1177/1359105315603471.
- [25] Gustafsson M, Windahl J, Blomberg K. Ten years follow-up of trauma-related psychological distress in a cohort of patients with acute traumatic hand injury. *Int J Orthop Trauma Nurs* 2012; 16: 128–135.
- [26] Seddon HJ. A Classification of Nerve Injuries. *Br Med J* 1942; 2: 237–239.
- [27] Wynn Parry CB. Update on peripheral nerve injuries. *Int Disabil Stud* 1988; 10: 11–20.
- [28] Purnell JQ, Palesh OG, Heckler CE, et al. Racial disparities in traumatic stress in prostate cancer patients: secondary analysis of a National URCC CCOP Study of 317 men. *Support Care Cancer* 2011; 19: 899–907.
- [29] Horowitz M, Wilner N, Alvarez W. Impact of Event Scale: a measure of subjective stress. *Psychosom Med* 1979; 41: 209–18.
- [30] Wohlfarth TD, van den Brink W, Winkel FW, et al. Screening for Posttraumatic Stress Disorder: an evaluation of two self-report scales among crime victims. *Psychol Assess* 2003; 15: 101–9.
- [31] Haagsma JA, Ringburg AN, van Lieshout EM, et al. Prevalence rate, predictors and long-term course of probable posttraumatic stress disorder after major trauma: a prospective cohort study. *BMC Psychiatry* 2012; 12: 236.
- [32] Sterling M, Kenardy J, Jull G, et al. The development of psychological changes following whiplash injury. *Pain* 2003; 106: 481–9.
- [33] Aaron DL, Fadale PD, Harrington CJ, et al. Posttraumatic stress disorders in civilian orthopaedics. *J Am Acad Orthop Surg* 2011; 19: 245–50.
- [34] Opsteegh L, Reinders-Messelink HA, Groothoff JW, et al. Symptoms of acute posttraumatic stress disorder in patients with acute hand injuries. *J Hand Surg Am* 2010; 35: 961–7.
- [35] Asmundson GJ, Norton GR, Allardings MD, et al. Posttraumatic stress disorder and work-related injury. *J Anxiety Disord* 1998; 12: 57–69.
- [36] Ghisi M, Novara C, Buodo G, et al. Psychological distress and post-

traumatic symptoms following occupational accidents. *Behav Sci (Basel, Switzerland)* 2013; 3: 587–600.

- [37] Brewin CR, Andrews B, Valentine JD. Meta-analysis of risk factors for posttraumatic stress disorder in trauma-exposed adults. *J Consult Clin Psychol* 2000; 68: 748–66.
- [38] Nyberg E, Stieglitz RD, Frommberger U, et al. [Psychological disorders after severe occupational accidents]. *Versicherungsmedizin* 2003; 55: 76–81.
- [39] Bitzer EM, Petrucci M, Lorenz C, et al. A comparison of conventional and retrospective measures of change in symptoms after elective surgery. *Health Qual Life Outcomes* 2011; 9: 23.
- [40] Kenardy J, Heron-Delaney M, Warren J, et al. Effect of mental health on long-term disability after a road traffic crash: results from the UQ SuPPORT study. *Arch Phys Med Rehabil* 2015; 96: 410–7.
- [41] Nota SPFT, Bot AGJ, Ring D, et al. Disability and depression after orthopaedic trauma. *Injury* 2015; 46: 207–12.
- [42] Michaels AJ, Michaels CE, Moon CH, et al. Psychosocial factors limit outcomes after trauma. *J Trauma* 1998; 44: 644–8.
- [43] Novak CB, Anastakis DJ, Beaton DE, et al. Biomedical and Psychosocial Factors Associated with Disability After Peripheral Nerve Injury. *J Bone Jt Surg* 2011; 93: 929–936.
- [44] Opsteegh L, Reinders-Messelink HA, Schollier D, et al. Determinants of return to work in patients with hand disorders and hand injuries. *J Occup Rehabil* 2009; 19: 245–55.
- [45] Dogu B, Kuran B, Sirzai H, et al. The relationship between hand function, depression, and the psychological impact of trauma in patients with traumatic hand injury. *Int J Rehabil Res Int Zeitschrift für Rehabil Rev Int Rech réadaptation* 2014; 37: 105–9.
- [46] Williamson E, Williams M, Gates S, et al. A systematic literature review of psychological factors and the development of late whiplash syndrome. *Pain* 2008; 135: 20–30.
- [47] Söderlund A, Asenlöf P. The mediating role of self-efficacy expectations and fear of movement and (re)injury beliefs in two samples of acute pain. *Disabil Rehabil* 2010; 32: 2118–26.

- [48] Benyon K, Muller S, Hill S, et al. Coping strategies as predictors of pain and disability in older people in primary care: a longitudinal study. *BMC Fam Pract* 2013; 14: 67.
- [49] Higgins J, Green S. *Cochrane Handbook for Systematic Reviews of Interventions Version (updated March 2011)*. version 5. www.cochrane-handbook.org (2011).
- [50] CRD (ed). *Systematic Reviews: CRD's Guidance for Undertaking Reviews in Health Care*. York: University of York, 2009.
- [51] NICE. *Low back pain and sciatica: management of non-specific low back pain and sciatica. Assessment and non-invasive treatments. Draft* <https://www.nice.org.uk/guidance/GID-CGWAVE0681/documents/draft-guideline> (2016).

